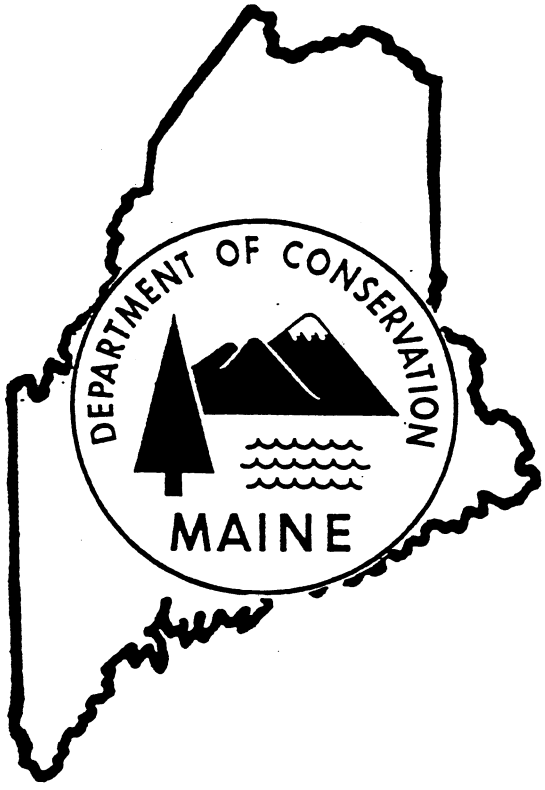
THE HEMLOCK LOOPER IN MAINE - 1992

AND A

FORECAST FOR 1993



by

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Introduction

Heavy to severe defoliation by hemlock looper, [Lambdina fiscellaria (Guen)], increased in Maine every year since defoliation was first mapped in 1989 (450 acres) until 1991. In 1992 acreage finally declined from the 1991 peak. In 1991, high egg densities and excellent survival of larvae throughout the feeding period resulted in 225,000 acres of heavy to severe defoliation. Egg density measured in the fall and winter of 1991 indicated reductions in outbreak severity in some areas but overall for 1992 a defoliated area only slightly (10 to 20%) smaller than the 1991 area was expected.

Although expected larval numbers were found during early season surveys, weather conditions in 1992 resulted in larval survival that was much lower than in 1991. Weather conditions that were good for infested trees and poor for larval survival resulted in a significant decrease in the predicted severity and extent of defoliation. Many areas, where heavy defoliation was predicted, received only moderate damage. A significant area, mostly in eastern Maine, did have heavy to severe defoliation but even in this area defoliation on 1992 needles was less than expected. Another closely related species of hemlock looper, L. athasaria, that is causing damage elsewhere in New England has been a problem in southwestern Maine but is currently at very low population levels.

Surveys of the hemlock looper infestation and technical assistance to industrial and private owners of looper damaged forest land required a considerable time commitment by the Maine Forest Service (MFS), Insect and Disease Management (I&DM) Division in 1992. Activities included expanded egg sampling in areas where spraying or accelerated harvest was considered, a survey of early larval densities to confirm egg predictions, assessment of larval development over time to help calibrate spray timing for numerous small control projects, and evaluation of the Bureau of Public Lands spray area. Looper moth activity was monitored using pheromone and light traps, aerial and ground surveys of defoliation were conducted, and an egg survey to predict 1993 damage was completed.

In addition, the MFS participated in three cooperative projects involving looper that were partially funded by focus funding grants provided by the U.S. Forest Service, Forest Health Protection. These projects were improvement of hemlock looper egg processing laboratory facilities at Old Town, assessment of the impacts of the current looper outbreak on affected host trees, and morphological comparison of larvae of the two looper species (L. fiscellaria and L. athasaria) currently causing defoliation in New England.

Larval Development

Seasonal development of hemlock looper larvae was tracked throughout the summer of 1992 to provide information to those interested in surveying or controlling looper populations. These data will also add to the historical record of this outbreak.

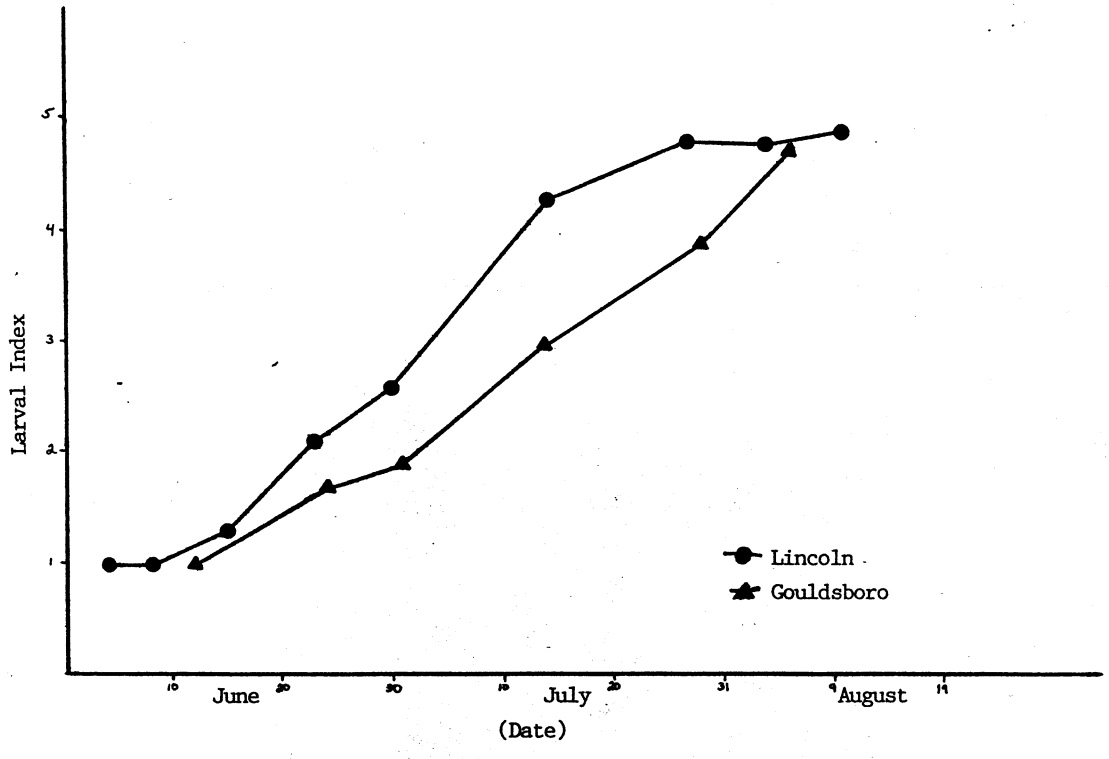
Development samples were collected periodically, from egg hatch through moth emergence, from two locations; in central Maine at Lincoln and on the coast at Gouldsboro. Additional development collections were made from several sites near planned spray areas. When larval development near these spray sites approached the spray threshold, the frequency of development samples was increased; following treatment sampling in these areas was discontinued. Larvae for each development sample were collected from branches of 3 to 5 overstory and 3 to 5 regeneration host trees (hemlock everwhere except Gouldsboro, where fir and white spruce were used). Larvae were placed in a vial of alcohol and taken to Old Town for instar determination. At the Lincoln site populations were high and only a small portion of each branch was needed to obtain 50 to 100 larvae. Although larval populations in Gouldsboro started fairly high, by the end of July populations had declined to the point that it was difficult to collect 50 larvae; by mid August larvae were very scarce everywhere in the stand. Ten samples were taken at the Lincoln site and eight from Gouldsboro during 1992.

A larval index was calculated for each site and date by multiplying the number of larvae per instar by the number of the instar and then dividing by the total number of larvae. For example, 25 1st instar plus 25 2nd instars would give an index of 1.5 (25x1 +25x2 = 75 /50 = 1.5). The ten development samples collected from Lincoln and eight samples from Gouldsboro in 1992 were graphed to show the progression of development over time (Figure 1).

The first egg hatch observed in 1992 was in Lincoln, Lakeville, and T4 ND on May 28. Very few larvae were seen, indicating that hatching had just begun. Larvae were very small and dark, indicating that they had hatched within a day of the observation. Hatch in the Lincoln area was approximately a week later than in 1991 and occurred about

the same time as the Lincoln egg hatch in 1989 and 1990. Development patterns for the 1992 season in central Maine areas were very similar to those seen during 1989 and 1990 and about a week slower than the 1991 development.

Figure 1. Hemlock Looper Larval Development Index for Lincoln and Gouldsboro Maine - 1992



The beginning of egg hatch was much later in coastal areas than that observed in Lincoln. Samples collected from Gouldsboro and other coastal areas between June 3 and June 5 had no evidence of egg hatch. A few scattered newly hatched larvae were found in coastal areas on June 9, and 63 first instar larvae were found in a Gouldsboro development sample on June 12. Development in coastal areas lagged behind the Lincoln area by 10 to 14 days throughout the entire 1992 development period.

Cool and wet weather in June and July resulted in slower than normal larval development for looper in 1992. Adverse weather conditions had the greatest effect along the coast and may have even delayed moth emergence to a point where mating and egg deposition were affected. Moths began to emerge in late August and early September and peaked in mid September in central Maine. Few moths were seen along the coast, however, until late September and moth activity there persisted well into October. Adverse coastal weather also seemed to lower larval survival.

Larval Observations

Population predictions generated from overwintering egg densities were checked in the spring of 1992 using a larval beating survey. Resources were not available to check all areas covered by the general egg survey, but many areas where landowners had expressed an interest in the looper infestation were checked. The method for this survey was similar to procedures used in Newfoundland. A meter square beating frame (a wood frame with white cloth stretched over the frame) was held under a single meter long branch on the sample tree. The branch was then beaten with a stick to dislodge larvae, which would fall to the cloth. The larvae were then counted to assess population density. This was done on three trees in each area sampled. While this method has limited precision, results seemed to reflect egg counts. Samples taken in areas where egg counts predicted low defoliation rarely produced larval counts exceeding 10 larvae per branch, whereas counts in high egg density areas usually exceeded 50 larvae per branch. Several areas with egg counts in the severe category had larval counts greater than 100 and some counts exceeded 200 larvae. In areas of moderate egg density, larval count ranging from 14 to 120 larvae per branch. Moderate egg densities produced the most variable larval counts.

Larval survival is difficult to assess for hemlock looper because larvae are very mobile and are easily dislodged from branches by wind and rain or during the sampling process. Larval counts from tree mid crowns are much lower immediately after a heavy rain than after a day without wind or rain. When large numbers of larvae are dislodged from the tree, the time necessary to climb back up the tree is highly variable. Also, many larvae are lost during this type of event. These sampling problems favor observations about survival over a predetermined and scheduled series of samples.

Larval survival was considerably higher in 1991 than it had been in 1989 and 1990 largely due to excellent weather during the 1991 development period. However, in 1992 weather conditions affecting looper development and survival were very adverse. For 1992 larval survival from the first to the fifth instar was estimated at from four to ten percent (versus 14 - 23 % in 1991), and represents the poorest survival seen during the current outbreak.

The primary reason for this decreased survival was probably the very cool, wet, and windy weather in 1992. Several wind and rain events occurred in 1992 that knocked larvae to the ground. Each time this occurred, many larvae were unable to regain a suitable feeding site and were lost.

Another factor known to significantly affect looper survival is disease. Larvae were not cultured for disease organisms in 1992 but populations were checked for obviously sick larvae or dead larvae. Very few sick or dead larvae were observed in central Maine but numerous dead larvae were reported from the area of the Gouldsboro development site.

Defoliation

An aerial and ground survey of 1992 hemlock looper defoliation was completed in late December and a generalized map of the area showing moderate (detectable, but <50% total defoliation) and heavy to severe (>50% total defoliation) damage was prepared (Figure 2). Heavy to severe defoliation was mapped on 68,074 acres and 150,000 acres received moderate defoliation. Most of the area were defoliation was noted in 1992 had been mapped as heavy to severe defoliation in 1991. Only about 5,000 acres of heavy to severe defoliation was mapped in new areas, mostly near Millinocket and Grand Falls. As in 1991, areas mapped in inland regions and coastal areas west of the Penobscot River contained predominantly hemlock. Areas mapped on the coast, east of the Penobscot and along the St. Croix River were predominantly fir. Figure 2 is only intended to show the general location of the 1992 looper damage. The MFS also prepared more detailed site specific maps that were sent to each municipality in the affected areas.

The 1992 defoliation survey was extremely difficult to conduct, requiring extensive ground observations to confirm aerial observations and complete. Looper larvae start feeding on new needles but soon change to older foliage and remain there until nearly all the old needles have been consumed. Early depletion of larvae due to poor survival in 1992 meant that in most areas surviving larvae were able to complete development on old needles and very little new growth was damaged. Damage on new needles was not sufficient to show from the air, and damage to old needles, even when severe, was hidden by new needles.

Many areas that lost more than 80 percent of their old needles and about 20 percent of their new needles (greater than 50 percent of their total foliage) could not be reliably identified from the air as having current damage. These trees appeared thin and off color in many cases but aerial observers could not determine whether the damage was caused in 1991 or 1992. Ground checks were needed in these areas to determine the time of defoliation. The need for ground checks, and some reevaluation from the air, extended the defoliation survey effort well into December.

Most of the acreage classified as heavy to severe defoliation was hemlock type found in east central Penobscot, northern Hancock, and central Washington Counties. Much of

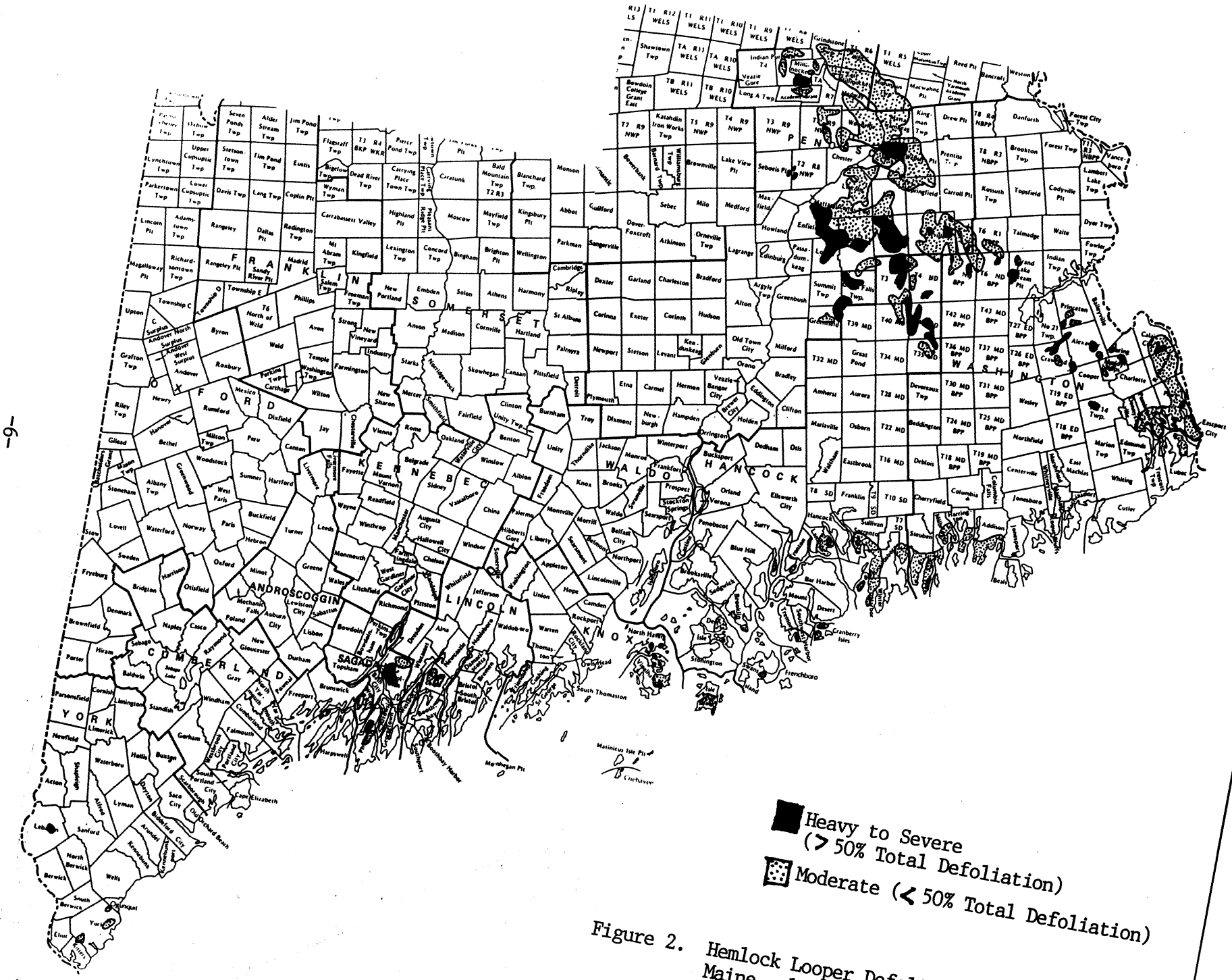


Figure 2. Hemlock Looper Defoliation for Maine - 1992

the area had received heavy damage in 1991 but new areas and expansions of some old areas were found. Part of this heavy to severe area was easily detectable from the air but other areas were added after ground checks revealed heavy 1992 defoliation to old needles.

Scattered small areas of heavy to severe defoliation were mapped near the coast and on islands from York to Washington Counties. Damage in stands west of Penobscot Bay was on hemlock whereas fir and white spruce were the affected hosts east of Penobscot Bay. The most heavily damaged coastal areas were near Bath in Sagadahoc County, and on points and islands in Hancock and Washington Counties.

Light Trap Survey

In 1992, the light trap operating period for 11 of the light traps in the MFS, I&DM Division's network (Figure 3) was extended into the fall to include the hemlock looper moth flight period. In 1991 nine of these traps had been operated during the month of September but some moth activity was noted in late August so in 1992 the operating period was moved up to August 17. It was hoped that this earlier date would capture any early moths and more fully evaluate the flight period. The choice of light trap locations to be extended was based on actual and potential looper defoliation in Maine and surrounding jurisdictions.

Hemlock looper moths were caught in all 11 light traps operated in 1992 (Table 1). Only two of the traps had a high moth catch (>300 moths in the season). The highest catch was at the Calais trap on the eastern border that caught 1,416 moths. This trap had caught over 5,000 moths in 1991. The other high catch (403 moths) was at the newly established South Berwick location in southwestern Maine. Moderate moth catches (70 to 299 moths) were seen at three sites; North Bridgton, Topsfield, and Washington. All other locations had low catches (<70 moths).

The majority of the moths trapped in 1992 were caught in mid September. Only three traps caught moths in August and of these only South Berwick caught a significant number of moths in August. The two southernmost traps, South Berwick and North Bridgton, had prolonged moth activity periods that lasted nearly the entire month of September and, in South Berwick, part of August. At one trap on the eastern coast, Steuben, nearly all the moths captured were caught at the end of September. Development was very slow in this area and moth activity was noted well into October. Late development in 1992 resulted in late moth emergence statewide but emergence on the eastern coastal area was especially late and may have affected mating and egg laying success.

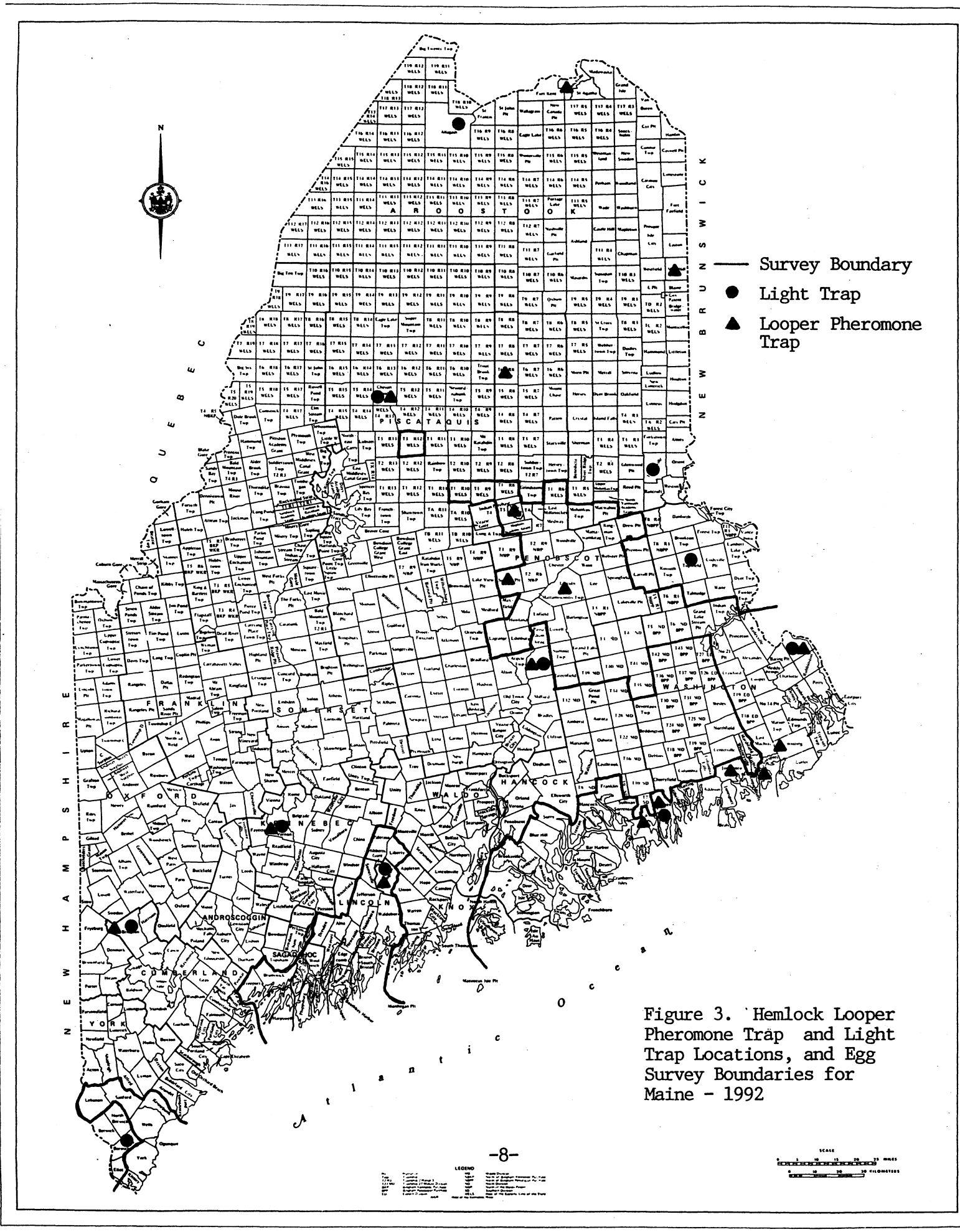


Figure 3. Hemlock Looper Pheromone Trap and Light Trap Locations, and Egg Survey Boundaries for Maine - 1992

Moth catches from all traps were examined to determine the sex ratio of the catch. In 1992 all eastern Maine traps caught many more females than males; southern Maine traps, caught many more males than females. These ratios match the 1991 pattern. Reasons for this apparent regional variation are unknown.

Table 1. Hemlock Looper (Lambdina fiscellaria) Light Trap Moth Catch Totals - Maine 1992*

Trap Location	# Males Moth Caught	# Female Moths Caught	Total # Moths Caught
Allagash	5	4	9
Calais	78	1,338	1,416
Chesuncook	11	5	16
Greenbush	2	4	6
Haynesville	3	2	5
Mount Vernon	9	25	34
No. Bridgton	93	15	108
So. Berwick	244	159	403
Steuben	8	21	29
Topsfield	35	50	85
Washington	63	10	73

*Light trap data provided by Dan Pratt - MFS, I&DM, Augusta

Moth Trapping With Pheromones

In 1992 the MFS used, for the first time, traps baited with hemlock looper pheromone to test their usefulness for evaluating moth abundance. Three looper pheromone baited traps were placed in a triangular pattern at each of 18 locations (Figure 3). Locations were selected to evaluate a wide range of looper infestation conditions ranging from no known population conditions in the trapping area to very high levels of infestation. No attempt was made to cover the known infested area with traps.

The mean moth catch per trap in areas assessed in 1992 (Table 2) ranged from 239 near Gardner Lake (Whiting) in southeastern Maine to two moths per trap at Frenchville in the northeastern part of the State. Four locations near known areas of heavy looper defoliation had counts over 170 moths per trap. Two locations that had no known heavy defoliation nearby also had high moth counts. These two areas were, however, downwind of known heavy areas. Two areas that had experienced heavy defoliation in 1991 (Lincoln and Gouldsboro) but showed population declines in 1992, had relatively low moth catches. All traps placed in central and southern Maine caught at least 20 moths per trap. Moth catch

was lowest in northern Maine but the location closest to a known infestation, Estcourt, did catch an average of 15 moths per trap.

Table 2. Hemlock Looper (Lambdina fiscellaria) Pheromone Trap Moth Catch Totals - Maine 1992

Location	# Hemlock Looper Moths/Trap
Bucks Harbor	226
*Calais	263
*Chesuncook	58
Estcourt	15
Frenchville	2
Gouldsboro	54
*Greenbush	173
Jonesboro	74
Lincoln	53
Mars Hill	8
Millinocket	236
*Mt. Vernon	20
*No. Bridgton	37
Seboeis Plt.	59
*Steuben	195
T6 R8	61
Whiting	239

*Indicates proximity to light trap

The MFS does not have enough data to relate pheromone trap catches to other life stages such as the 1992 egg densities or 1993 larval populations. The MFS is likely to use a low level of pheromone trapping again in 1993 to study the value of this survey as a predictor of population levels.

1992 Predictive Egg Survey

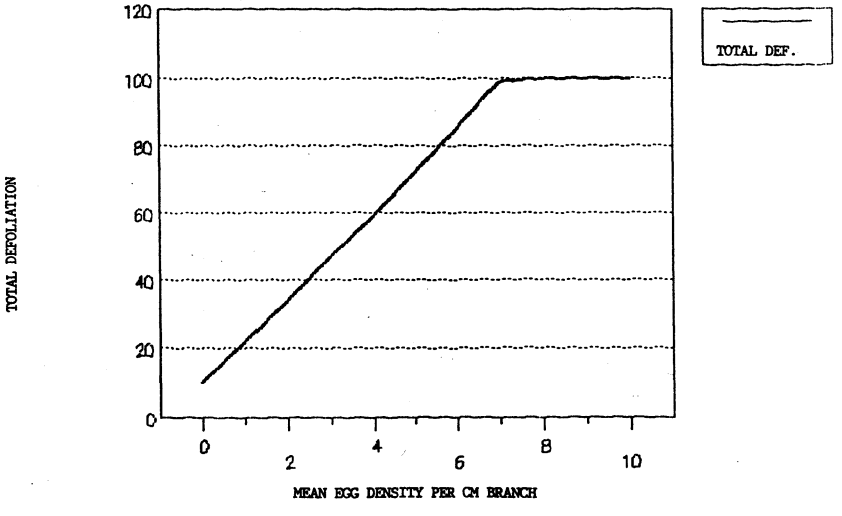
The MFS conducted a survey of hemlock looper egg density in 1992 in and near areas of defoliation to provide a generalized defoliation prediction for the infested area and to determine population trends throughout the state. To accomplish these general goals, a relatively low density sampling format of one or two sample points per infested town was considered adequate. Sample density was increased in many areas where landowners requested or were expected to request more information in order to make looper management decisions.

The 1992 survey began in early November and was not completed until January 30, 1993. The extended survey period was due to a shortage of Division resources.

The egg sampling method was the same as that used in 1990 and 1991 except that sampling branches from regeneration trees was discontinued. Data from an MFS study of egg density versus defoliation, (Trial and Trial, 1992)* showed that this change could be made without decreasing sample accuracy. Branches from overstory trees (three) were collected at each sample site from either hemlock, balsam fir, or in a few locations white spruce. Branches were taken to the MFS laboratory facility at Old Town and eggs were counted using an egg washing method developed in Newfoundland and modified for use in Maine. The average number of eggs per branch from the three branches was used to predict 1993 defoliation.

The new set of egg density and defoliation data collected during the 1991 study was used to develop a new predictive egg density to defoliation relationship (Figure 4) that was used for this predictive survey. This new relationship was similar to the relationship developed in 1990 but it does show that somewhat fewer eggs are needed to produce the various levels of defoliation. The new relationship was based entirely on overstory branches which allows for the elimination of regeneration branches from the sample. Because it was developed from data that covered a full range of egg densities and a large geographical area, it is thought to be more accurate than the previous relationship.

Figure 4. Predicted Total Defoliation on Hemlock based on Average Mid-crown Egg Density per 100 cm Branch



*Trial, H. and J. G. Trial. A Method to Predict Defoliation of Eastern Hemlock [Tsuga canadensis (L.) Carr] by Eastern Hemlock Looper [Lambdina fiscellaria (Gn.)] using Egg Sampling. Me. Dept. of Conserv., For. Serv., I&DM Div.. Tech. Rep. No. 31. 12pp.

The efforts to develop a predictive survey method have shown that many factors other than egg density can have profound impacts on the amount of defoliation ultimately realized in an area. Factors such as the amount of foliage available, number of years looper has been in an area, stand site quality, weather conditions the next season, and whether the population in an area is healthy can greatly affect defoliation.

Boundaries of the 1992 egg survey are shown in Figure 3. A total of 288 samples have been collected and processed to date, making the 1992 survey approximately 32 percent smaller than the 1991 survey and approximately the same size as the 1990 survey. The decrease in the size of the general survey was due to a significant decrease in the extent of heavy to severe defoliation in 1992 and by the decision to reduce general sample density to one collection per town in many areas.

Egg density measured during the 1992 survey is summarized on a map (Figure 5) to show population trends and the location of the higher egg density levels throughout the state. This egg density map was used in combination with the aerial defoliation map to predict the potential level of damage expected in 1993. Past defoliation was considered because experience with the present hemlock looper infestation has shown that the ultimate level of 1993 defoliation will depend significantly on the level of 1992 defoliation.

The actual level of defoliation experienced in 1993 will be highly dependent on larval survival, weather conditions, and natural population collapses due to disease. Obviously, good weather for larvae and high survival will increase defoliation as will drought conditions, which stress host trees. A rapid buildup of disease organisms that control looper population could cause rapid population collapse and low defoliation even in areas of high egg density.

During the current hemlock looper outbreak the MFS has observed extreme variability in egg density within individual towns and at times even within the same stand. Because looper population densities are so extremely variable, it is very likely that areas on the general map that are shown as heavy will have light areas and areas depicted as light may have patches of heavy defoliation in 1993. The best description of the map categories is probably, "areas where the majority of susceptible stands are expected to receive the defoliation specified". To attain a reliable prediction of expected defoliation for a potential spray block or to influence management of a parcel of commercial forest land, a much higher sample density would be required.

The largest area of high and extreme egg density evident from the 1992 egg survey is a band of forest, five to 15

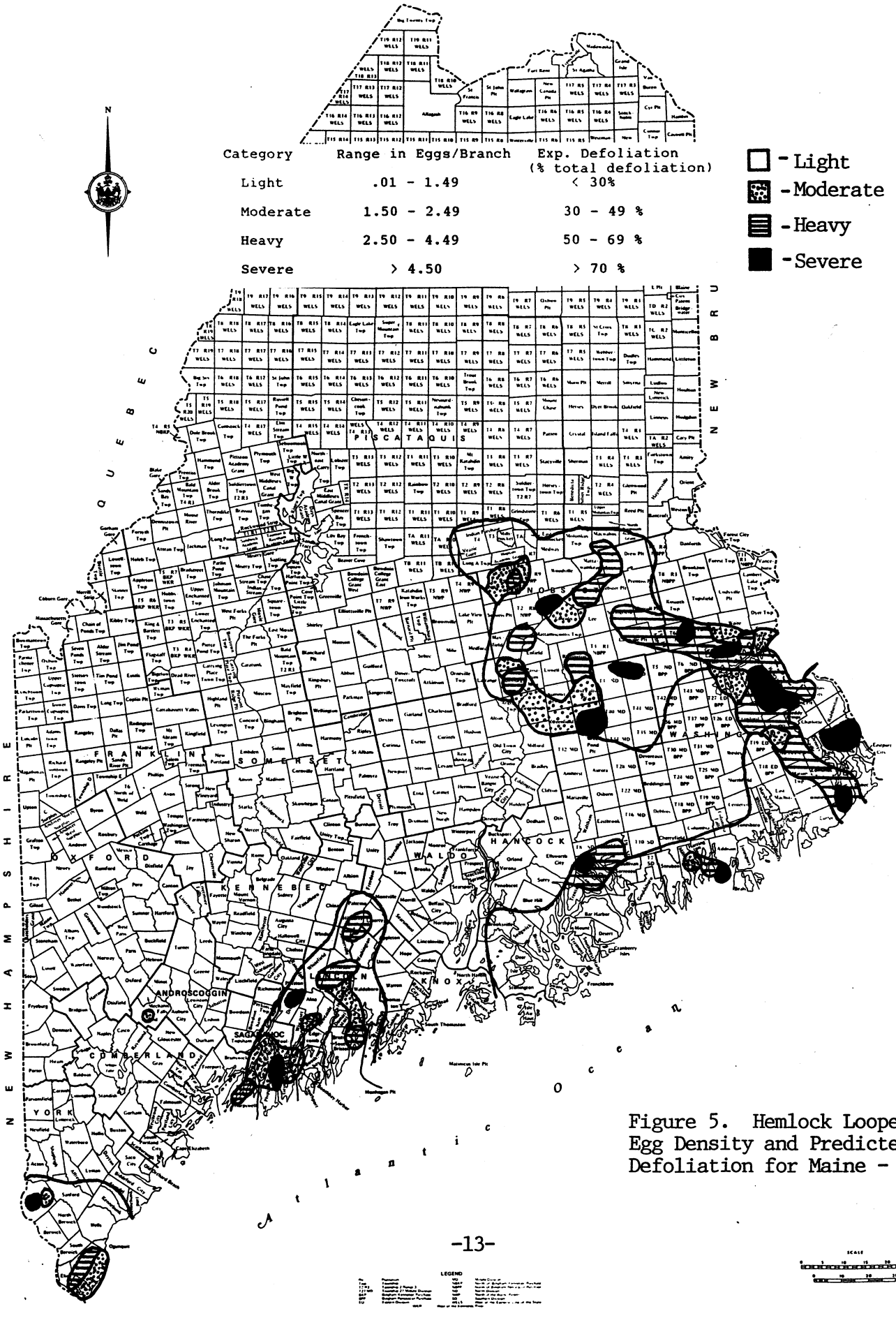


Figure 5. Hemlock Looper Egg Density and Predicted Defoliation for Maine - 1992

miles wide, stretching south east from east central Penobscot County to the eastern Washington County coast. The affected host on the western end of this band is hemlock and fir is the most common host in the east. Some stands near Calais contain both fir and hemlock.

Large areas of mixed moderate, heavy, and severe egg density found in central Penobscot County in 1991-92 decreased in size considerably in 1992-93. Smaller areas of heavy and severe egg density were found in the general vicinity of Lincoln. Significant new areas of moderate and heavy egg density were found south of Lincoln along the Penobscot River and in the Greenfield area. These areas had low egg densities in 1991-92 and did not receive serious defoliation last season.

A significant reduction in egg density was noted in coastal sections of Hancock and Washington Counties in the 1992-93 survey. Looper caused serious defoliation and significant mortality to fir and spruce in this region in 1990 and 1991. However, damage decreased in many areas in 1992 and the forecast for most of the region is for low populations for 1993. Small areas of heavy to severe populations remain scattered through the region. A larger area of heavy population was found a short distance from the coast near Franklin.

Populations in the Bath area are predicted to be moderate to severe in 1993 and looper may cause significant damage in stands that were hard hit in 1991 and 1992. An unexpected development seen in this year's egg survey was the reoccurrence of heavy populations in parts of Lincoln County. Populations in this area were thought to have collapsed after severe defoliation in 1989 and 1990. Egg density in Lincoln County was very low in 1991.

Areas of moderate to heavy egg density in York County seem to have expanded even though the area did not receive much heavy defoliation in 1992. Many areas like York County, where poor weather conditions in 1992 protected stands temporarily continue to have damage potential from looper.

Impacts

Two studies of the impact of the current hemlock looper infestations on host trees are underway. The larger study began in 1990 and has 36 assessment locations in Maine, New Hampshire, Massachusetts, and Vermont. Maine has 26 of the survey areas and is evaluating impacts of L. fiscellaria on hemlock (21 sites) and on spruce fir type (5 sites). The other New England states have a total of 10 sites, all hemlock, and all were attacked by L. athasaria.

The other impact study in progress is designed to evaluate damage by looper in "worst case" sites in Maine. The most severely impacted sites in Maine were not well represented in the initial impact study due to the spotty nature of the heavily damaged areas and because two of the plots in the original study that were heavily damaged were salvaged. In this "worst case" study, several of the most severely damaged areas were mapped from the air and were subsequently surveyed on the ground to determine the extent of looper impacts. When losses in this type of area are determined, total impacts can be calculated by expanding losses over similar areas mapped aerially. Most areas salvaged because of looper damage had similar damage as that seen in this study and could be added to the total impact figure.

Neither impact study has progressed enough to provide quantitative results. Data from the "worst case" study should be available by the spring of 1993. Complete results from the larger study will take longer to process. However, some general observations can be made based on an interim data assessment prepared in 1992.

In general, the most severe impact of the current looper infestation will be very spotty and unlike spruce budworm, heavy losses are not likely to occur over large areas. Looper caused mortality to hemlock seems to be extremely localized, and poorly understood factors like water stress, stress from partial harvesting, and sites near water (islands, points, and shoreline) that might concentrate looper populations seem to determine the extent of mortality in an area. Most forest stands that do not have one or more of these stress factors seem to have survived the present outbreak with minor top dieback and intermediate tree mortality.

If in 1992, as in 1991, weather had been favorable to looper larval survival the impact picture might have been very different. The impact of a specified population level on host trees varies considerably depending on weather and other factors prevalent during the feeding season. The warm and very dry conditions seen in 1991 resulted in much higher levels of damage in high population areas than during any other period of the current looper outbreak. Considering the high larval numbers early in 1992 and the reduced foliage compliment resulting from 1991 defoliation weather conditions favorable to looper larvae in 1992 would have resulted in the death of many stands that are now surviving.

Despite an apparent reprieve in looper damage due largely to cold wet 1992 weather, impacts in many areas were still significant. In central Penobscot County many hemlock stands were damaged so badly by the fall of 1991 that landowners rescheduled harvest plans and in many areas began

immediate salvage. Nearby stands that were not harvested show significant hemlock mortality.

In central Penobscot County and southern Washington County several residential and recreational property owners experienced heavy losses of hemlock and young fir trees near their homes and camps. Some owners were able to spray their land with Bt. (Bacillus thuringiensis) and thus avoid heavy losses but these owners were in the minority. Many owners will be faced with expensive or time consuming cleanup efforts.

Landowners in coastal areas of Washington, Hancock, and Sagadahoc Counties also lost many trees to looper around their homes and camps. Most hard hit areas were on the shore, on points, or on islands. Losses in these areas were focused on young fir and white spruce trees although large mature white spruce killed in some areas. In Sagadahoc County mature and young hemlocks were killed.

In eastern Washington County several stands of young balsam fir were killed or heavily damaged by looper. Many of these stands were used to produce balsam fir tips for wreath making but looper damage in 1991 and 1992 will prevent tipping on survivors for several seasons. Some Christmas tree growers in Washington and Hancock Counties had to treat their plantations to prevent significant damage by looper.

Hemlock Looper Management Activities

Both industrial and small private landowners, affected by the current looper outbreak, have been very active in management of this pest's impacts to reduce losses. Most industrial landowners have attempted to reduce losses by salvage cutting and adjusting cutting plans. Large landowners have first selected the worst of their infested land by examining MFS or their own aerial defoliation maps and the MFS general egg density survey. Based on these data and company cutting plans, landowners have selected stands where specific population and damage samples are necessary to refine their looper management strategy. Industry staff have collected looper egg and damage samples which are examined and evaluated by the MFS. Landowners have used these evaluations to shift normal harvesting or salvage cuts to areas where looper represented a significant threat to the forest.

Control of looper damage by spraying was again employed successfully in 1992 by several owners of residential or recreational property. Generally these private owners are primarily concerned by the effect of looper mortality on property values and aesthetics. Several property owners in coastal Maine and others with lots on inland lakes are planning spray operations in 1993. Because most affected

residential properties are near people and water, the biological agent Bt. is recommended for these treatments. Properly timed and executed Bt spray treatments proved successful in 1991 and 1992. Individuals considering spray control are generally dependent on the MFS for survey information, data evaluation, and spray timing.

Another important aspect of looper management on residential land is the removal of trees killed by looper. On many properties, especially on coastal islands, these dead trees represent a significant fire hazard. Removal of looper killed trees can be expensive to some owners.

Some owners of looper infested forest land will decide to do nothing to lessen impacts. Considering the unpredictable and spotty nature of looper mortality, some of those who choose not to attempt to manage impacts will be successful.

Future Plans

Several areas of heavy to severe egg density remain scattered throughout the southern half of Maine and good weather in 1993 could result in a looper resurgence in many areas next summer. In general, however, the looper outbreak in many parts of Maine shows signs of collapse in the near future. Overall, the area of heavy to severe defoliation in 1993 is likely to be smaller than the 1992 area and major new areas are not expected.

MFS surveys and evaluations of the looper populations, damage, and impacts will continue until the outbreak subsides. Technical assistance will be provided to affected industrial and private landowners. Processing and evaluations of site specific egg and damage samples should be completed by March and recommendation on management options will be forwarded to the various individuals and companies. The MFS will assist individuals and groups in planning, timing, and implementing spray projects for June of 1993.

Impact studies on established plots and other selected damaged areas will continue. A report on two years measurements of 26 permanent impact plots will be available in the fall of 1993. This study is partially supported by a U.S. Forest Service grant.

Finally, the MFS will continue to observe and evaluate all aspects of the current hemlock looper outbreak. This includes evaluation of biological observations made in Maine and other affected jurisdictions to better understand the outbreak.